GENERAL BIOLOGY.

Effect of Chemical and Physical Agents upon Growth. — The second part of Dr. Davenport's useful *Experimental Morphology* [1] will be welcomed by all students of the theoretical aspects of biology. This volume deals with the effects of external conditions upon growth. The first chapter is devoted to the consideration of the phenomena of normal growth, which is defined as increase in volume. Three factors are recognized — increase of formed substance, of plasma (protoplasm), and of enchylemma. Special emphasis is laid on the importance of the imbibition of water at the period of most rapid growth. Characteristic curves are given showing at first a rapid increase in the rate of growth, which soon reaches a maximum, and then more gradually declines to zero. The final cessation of growth is to be explained by special reasons for each species, and is not due to any general law.

The following chapters treat of the effects upon growth of chemical agents, water, density of the medium, molar agents, gravity, electricity, light, and heat. In each of these the effect of the agent considered is treated first in regard to its effect upon the rate of growth, and then as to its effect upon the direction of growth. The molar agents affecting growth include contact, rough movements, deformation, wounding, and the flow of water. A final chapter is devoted to the effects of certain complex agents upon growth and to general conclusions.

The book has comparatively little to do with theory. It is essentially a very careful and complete résumé of the records of laboratory experiments in the field which it covers. The only experiments that have not been published before are those described on page 365. They were made by Messrs. Frazeur and Sargent in the zoölogical laboratory at Harvard, and their object was to determine the effect of concentration of medium upon the rate of regeneration and fission in certain annelids — a species of Nais and *Dero vaga*. This lack of newness does not lessen the value of the work, however. A glance at the extensive bibliography at the close of each chapter is enough to convince one of the service that the author has performed for biology by bringing together this immense amount of material in so compact and accessible a form.

[1] Davenport, C. B. *Experimental Morphology*, Pt. ii. Effect of Chemical and Physical Agents upon Growth. New York, Macmillan, 1899. pp. 281–509. Illustrated, 8vo.

Persons unfamiliar with the present trend of biological research will be surprised at the large amount of quantitative work exhibited in this record of experiments. Wherever possible, the author has pointed out the adaptive character of the reactions observed in the laboratory. Some readers may be disappointed to find that he has not gone farther than this, and discussed the effects of chemical and physical agents upon the forms of animals and plants in the state of nature. The reason that he has not done this is, doubtless, in the first place, the fact that in nature the effects of these agents upon growth is complicated with their effects upon differentiation, which will be treated of in a later volume; and, in the second place, the lack of material. When the effects of agents under control in the simplified conditions of the laboratory are understood, we may hope to solve the problem of form as presented under the complex conditions of the natural habitat. The work under review is an important step in that direction.

In most cases where the direction of growth is changed in response to stimulation, true tropism, the result is to place the organ in a more favorable position. It is clearly adaptive. The reactions classed under the head of electrotropism, on the other hand, cannot be shown to be adaptive, because organisms never meet with the stimulus employed in the state of nature. Yet the reaction takes place with as much precision as the response to light or heat.

The most interesting of the general conclusions is in regard to the phenomena of "attunement." In several kinds of tropism, as the strength of stimulation is increased, a critical point is reached where the effect changes from positive to negative. This critical point differs in different species, and may be regarded as indicating an optimum intensity to which the organism is attuned. How is this attunement established? Natural selection is rejected and "a cause more consistent with sound physiology" is sought.

It has been shown that the effects of various agents persist after the stimulus has been removed. This "after-effect" seems to show that the agent causes a change in the protoplasm which is more or less permanent. This permits the accumulation of extremely slight effects. When, however, the repeated stimuli are each great, it is not an accumulation, but a diminution of response that is noticed. The organism becomes gradually accustomed to the stimulus and ceases to respond. It is acclimated. The author's hypothesis to explain this is that the chemical change which leads to the response becomes a permanent characteristic of the protoplasm so that no

further response to that particular strength of stimulus is possible. This individual attunement may persist, and may be inherited and thus initiate a racial attunement.

The author does not claim that this is a complete explanation of the facts. It is merely a tentative hypothesis. But it is almost too soon to attempt even an hypothesis, for if we try to compare the critical points of the various kinds of stimuli in their effects upon the rate and the direction of growth, in order to see what relation exists between them and how they are related to adaptive responses of the organism, we find the data often contradictory and always inadequate. For example, if we compare the tables given on page 439, we find that of the seven species mentioned in Table 45, only four are to be found in Table 46. Moreover, the first mentions the organs affected, while the second leaves us in doubt as to whether we are dealing with root or stem. Similar difficulties arise in an attempt to compare the table on page 454 with those on pages 464 and 465. All this goes to show that, in spite of all that has been done, more work is needed, and the author's hypothesis will be of value if it serves no other purpose than to stimulate research from a broad point of view.

We notice few errors and omissions. On page 411, line 4, for *plant* read cylinder. The important work of Martin and Friedenwald[1] on the effect of light upon metabolism in animals has been overlooked. On page 440 a diagram of the spectrum is given, showing an interesting coincidence between the point of maximum retardation of growth and that of no phototropic effect. But this coincidence is not mentioned in the text.

R. P. B.

Variation Statistics.[2] — In this work Duncker provides naturalists with the new tool which the English anthropologists, zoölogists, and mathematicians have developed. Many of the works of the mathematicians, especially the invaluable treatises of Pearson, have been beyond the mathematical training of most biologists. In this paper the results of these treatises are given in a comparatively simple fashion. Great stress — relatively too much in the reviewer's opinion — is laid on the methods of constructing the various types of

[1] Martin, H. N., and Friedenwald, J. Some Observations on the Effect of Light on the Production of Carbondioxide Gas by Frogs, *J. H. U. Studies*, iv, 5, p. 221, 1889.

[2] Duncker, G. Die Methode der Variations-Statistik, *Ant. für Entwickelungsmechanik der Organismen*, Bd. viii, pp. 112–183. Feb. 21, 1899.